

# *Optically Isolated HV-IGBT Based 5-MW Cascade Inverter Building Block for High Power Applications*

**Paul Grems Duncan  
Airak, Inc.**

**U.S. DOE Small Business Innovative Research (SBIR), Phase II Grant  
DOE 2002 Project**

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Paul Grems Duncan  
(703) 330-4961  
[pduncan@airak.com](mailto:pduncan@airak.com)

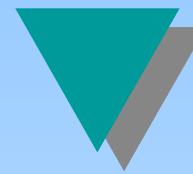
# *Project Goals*



Develop and test an advanced prototype three phase, 5 megawatt inverter system based upon HV-IGBTs switches with complete optical isolation (control and sensing) between the high power subassemblies and the low power control and signal processing hardware.



# Team Members



**PRODUCT DEVELOPMENT  
COMMERCIALIZATION  
MANUFACTURING**



**Pre-production  
Engineering  
Support**

**Power Conversion  
System  
Design & Testing**



**Funded  
Research**



**Products**

**High-Power Inverter  
Applications**

**Optical Transducers  
for High-Power  
Applications**



**Optimized  
Sensor  
Elements**

**System  
Specifications**

**Technical  
Oversight**



**Testbed  
Validation**



**Sandia  
National  
Laboratories**

# *Motivation*



- There exist no cost-effective, efficient power conversion topologies for high-power markets.
- High-power conversion systems are largely based upon smaller conversion systems with applied scaling rules, e.g., a 5-MW system ~ size of 10, 500 KW systems.
- Solution: Optical Sensor Technologies + High-Voltage IGBT Power Systems + Advanced Heat-Pipe Cooling Solutions



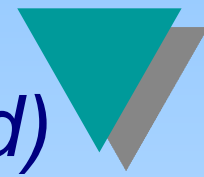
# *System Advantages*



- HV-IGBT Topology Allows:
  - Elimination of Current Snubbers and Voltage Clamps
  - Simplified Gate Drive Circuitry and Isolation
  - Access to Control Schemes that Permit Increased Efficiency and Reliability
  
- Optical Transducers and Interfaces Allow:
  - Intrinsic Isolation
  - EMI Immunity => Increased Reliability
  - Increased Equipment and Personnel Safety



# *System Advantages (Cont'd)*

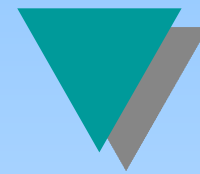


## ➤ Integrated Heat-Pipe Cooling System Allows:

- Life-Cycle Cost Reduction over Conventional Pumping Systems
- Lower Maintenance Requirements
- Higher Reliability



# *Dual-Use Applications*

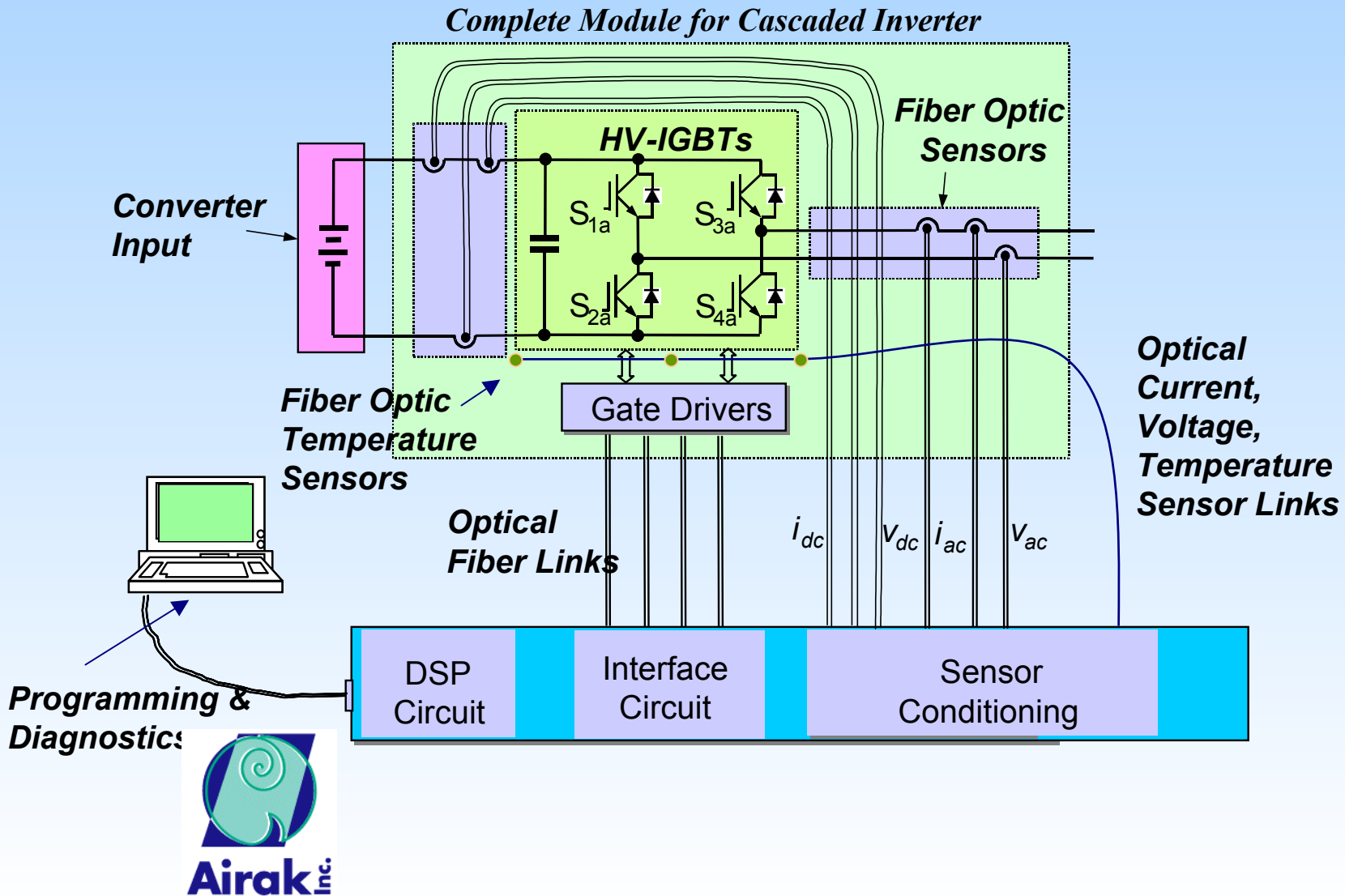


- Emergency Power Markets
  - Short Term Ride Through Appl.
  - Longer Term UPS Applications
- Distributed Energy Markets
- Advanced Power Conversion Technologies
  - Fuel Cell Manufacturers
  - Flywheel Manufacturers
  - Wind & Hydro Turbine Mfrs.
  - Solar Manufacturers
- Military Markets
  - Fuel Cell Applications
    - ✓ Submarines
    - ✓ Afloat Forces
    - ✓ Forward Deployed Forces
  - “All Electric” Ship
    - ✓ Zonal Power Distribution
    - ✓ Prime Mover Power Conversion



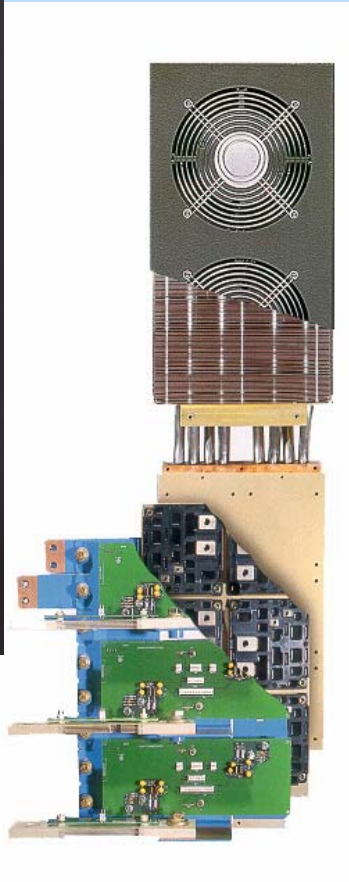
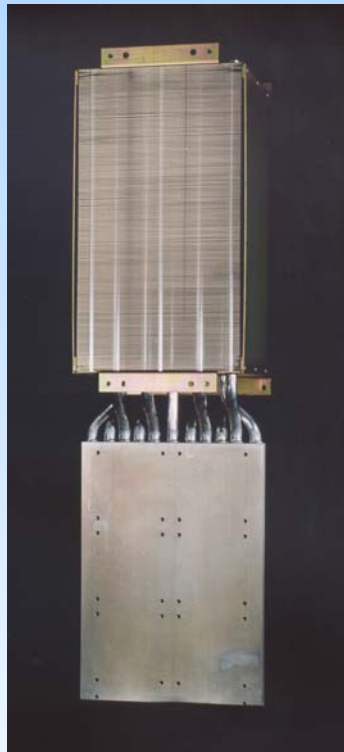
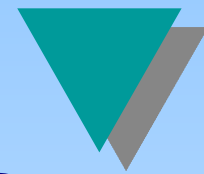
# Single Phase Building Block

## Sensor & Control Configuration





# *Therma-Charge™ Multi-Kilowatt Heat Pipe Heat Sink*



**Power Rating: 10,000 watts**

**Nom. Air Flow: 600 CFM**

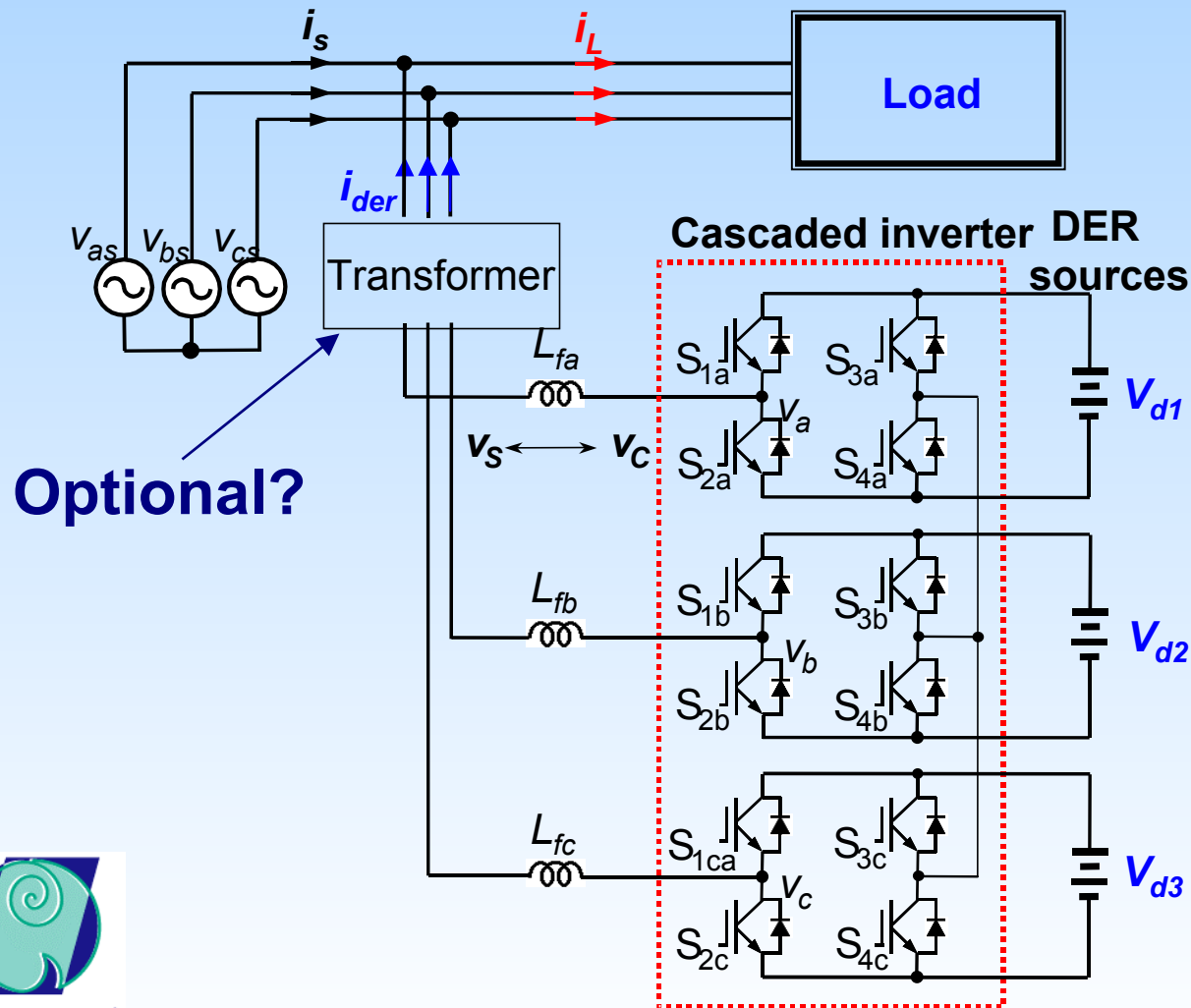
**Working Fluid: Water**

**Operating Range: 40° C – 180° C**



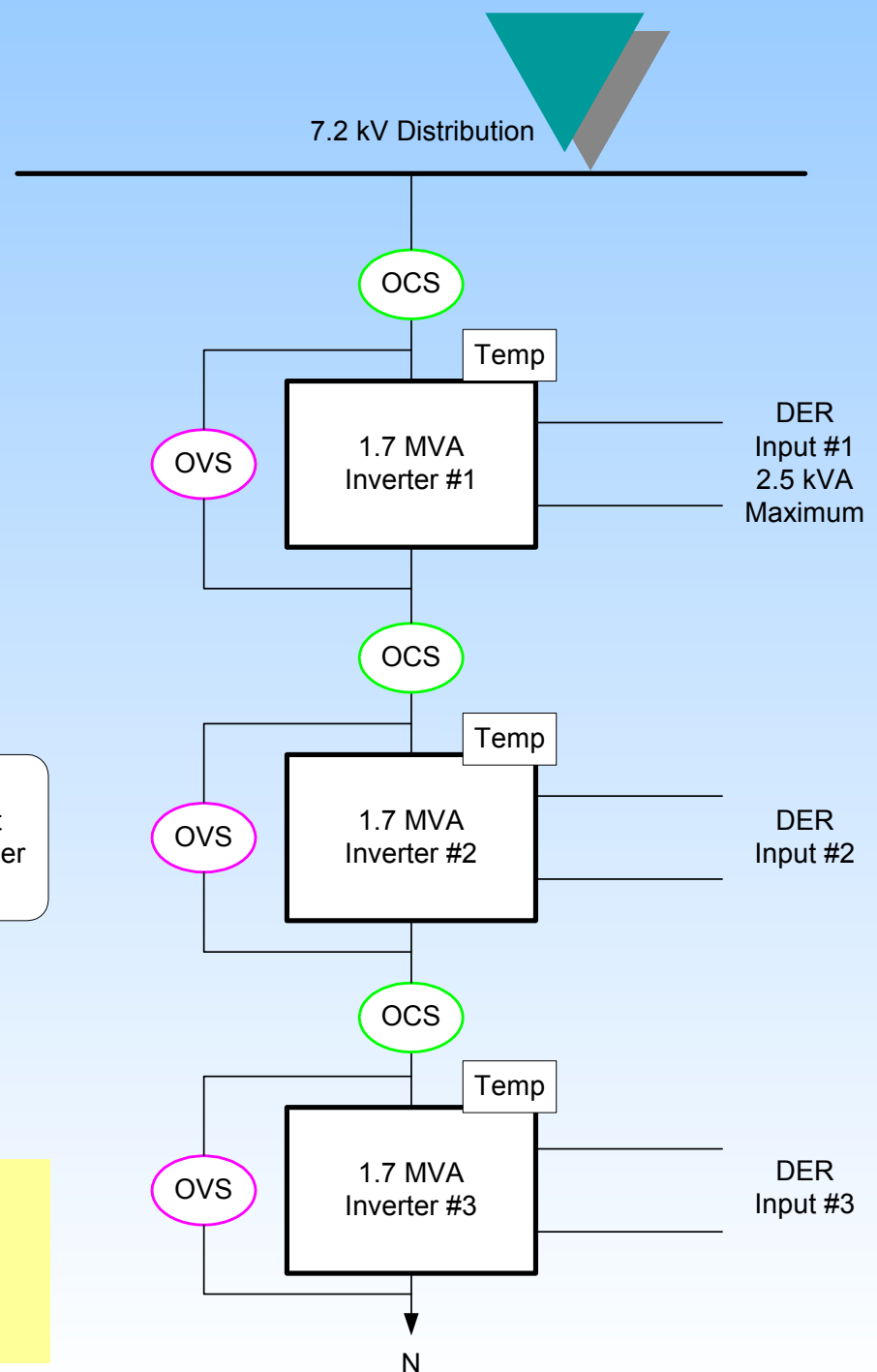
# 3-Phase System Configuration

## Primary Test Configuration



# Transformerless Direct Connection

3-Unit  
Controller



# 5-MW 3-Phase Inverter

## Concept Packaging

AC/DC  
Interconnections

Inverter A

Inverter B

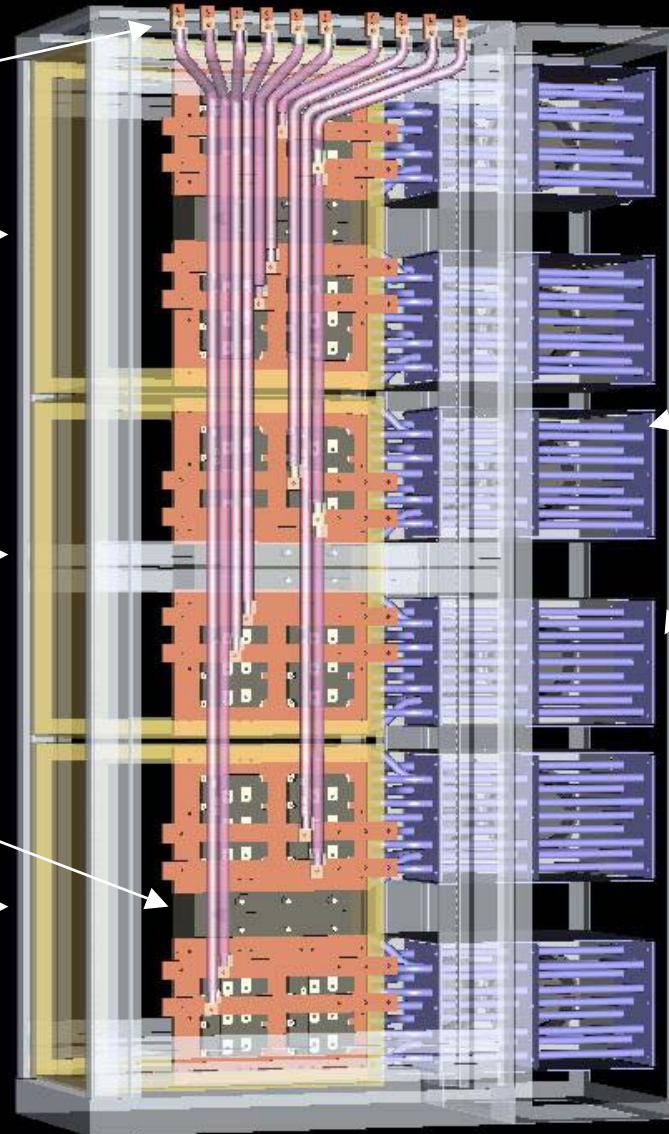
Bus Caps  
(3)

Inverter C

88"

ThermaCharge  
10kW Cooling  
Assys + Fan  
Packs (6)

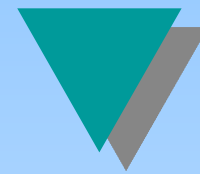
48"



# *Program Status as of 11/19/02*

- Successfully Demonstrated 1400 kVA Single Phase Leg in March 2002 (details available @ [www.airak.com](http://www.airak.com))
- Currently In Month 5 of 24 Month Program
- Virginia Tech Subcontract to Deliver 300 kW Test Rectifier Started in Aug '02
- All Major Subsystems Have been Identified and Quoted
- 1400 kVA Single Phase System has been Transferred to Airak for Closed-Loop Control System Development & Testing

# *Program Status (Cont'd)*



- The Integrated System Controller is Being Developed
- Optical Current Sensors are Undergoing Extensive Temperature Testing to Ensure Long-Term Performance
- Optical Temperature Sensors are Ready for Integration & Testing
- The Packaging for the Optical Voltage Sensors is being Developed for Integration into the Busbar.

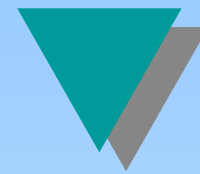


# *Pending Major Milestones*

- ThermaCharge Integration & Testing into Phase I 1400 kVA Phase Leg (Feb '03)
- Phase II Single Phase Leg Close-Loop Testing (Jul '03)
- 3-Phase Low-Level (<300 kW) Testing (Jan '04)
- 3-Phase Inverter Delivery to AEP (NLT Apr '04)



# Acknowledgements



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  - Dr. Imre Gyuk, U.S. Dept. of Energy
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